Effect of Disasters and Climate Change on Poverty and Inequality in India

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Abstract
This study assesses the impact of disasters and climate change on poverty and inequality in India from 1900 to 2018. Country level analysis shows that natural disasters, mainly flood, is increasing over time. Almost 41% of the total deaths in the period 1900–2018 occurred between 1991and 2018 due to natural disasters. Climate change variables show a whopping 545% increase in the CO_2 emissions, 7% increase in the mean temperature, and a mammoth 835% increase in annual rainfall from 1960 to 2014. Poverty figures show that there is a 23.4% decline in poverty from 1993–94 to 2011–12. Inequality in India has increased from 0.33 in 1973–74 to 0.36 to 2011–12. The calculated correlation values show that the rate of poverty is negatively associated with CO_2 emissions, annual mean temperature, and annual rainfall. A state-level analysis shows that the correlation between rainfall and inequality is positive. State-wise panel data model analysis from the period of 2004–05 to 2011–12 shows that natural disasters and climate change, which are measured by the change in rainfall, has a positive effect on state-level poverty and inequality in India. Finally, we suggest that eco-friendly economic growth strategies and redistributive policies are essential for sustainable economic growth in India.

Key Words: Disasters, climate change, poverty, inequality, India

JEL Classifications: Q54, Q53, I32, D63

1. Introduction

The Nobel Prize in Economics in 2018 has considered climate change in the long-run macroeconomic analysis, as it is one of the main culprits behind the natural disasters. Recently, across the world several extreme natural events have been frequently occurring such as floods, earthquakes, and tsunamis. For example, the recent earthquake and tsunami on the Indonesian island of Sulawesi killed about 832 persons in 2018. The severe flood in the Indian state of Kerala in this year was the result of unusually high rainfall during the monsoon season. It was the worst floods ever witnessed in Kerala in nearly a century, which left 12 lakh people homeless and more than 300 people dead. Property worth more than Rs 20,000 crore was lost. As these extreme events are associated with a large amount of deaths and destruction of assets, it compels us to study their effect on the behavior of household, individuals, and aggregate economic outcomes, such as poverty and inequality. The extreme weather events create poverty traps, which are linked with health, education, livestock, and other assets. The Intergovernmental Panel on Climate Change's (IPCC) Working Group II (WG II) report mentioned that climate change will impact the world severely and the risks are intensifying. India is especially vulnerable since it houses 33% of the world's poorest people. India is conventionally vulnerable to natural disasters on account of its unique geo-climatic conditions. Swiss Re reports (2006 and 2007) indicated that among the 20 worst catastrophes in terms of victims, India has the most victims compared to other countries.

Natural disasters are a common occurrence in developing countries, and there is a growing concern that they may become more frequent due to climate change (Aalst, 2006). Hochrainer-Stigler et al. (2011) addressed household-level disaster financing strategies of the poor in developing countries within the context of current poverty trap discussions. The study found that due to financial shocks (arising from floods and droughts), the risk of households falling below the subsistence level and into a poverty trap is high. Disasters result in significant economic damage and even cause large-scale deaths. A report by Organisation for Economic Co-operation and Development (OECD) on "Poverty and Climate Change Reducing the Vulnerability of the Poor through Adaptation" indicates that climate change is happening on a rapid scale and will increasingly affect the poor. Therefore, there is a need to integrate responses to climate change and convert adaptation measures into strategies for poverty reduction to ensure sustainable development.

Zhou et al. (2017) assessed the impact of climate change on poverty (measured by malnutrition and infant mortality) reduction in China, India and Senegal. They found that the indicators of climate change are significantly correlated with those of poverty and also of agriculture and human well-being. Pink (2016) mentioned that the marginalization of minority groups and vulnerable populations in India is widespread and this reality extends to water, health, and security. Water scarcity, climate change, drought, flooding, water delivery infrastructure at the rural level, extreme poverty, waterborne diseases, and water pollution are combined challenges that confront the Indian government and her people. Kar and Das (2015),using a theoretical and empirical exercise, explored the effect of climate change on farmland value and use a counterfactual measure of the farm revenue on rural consumption expenditure. They found a discerning impact of climate change on the net revenue and well-being of rural people.

Gupta et al. (2014) found that paddy (India's leading food crop) is sensitive to climate variables but also to fertilizer use and irrigation. They also proposed several policies detailing how India’s agriculture can adapt to climate change. Dataret al. (2013) investigated the impact of small and moderate disasters on childhood morbidity, physical growth, and immunizations by combining household data covering over 80,000 children from three waves of the Indian National Family and Health Survey with an international database of natural disasters (EM-DAT).They found that that exposure to a natural disaster in the past month increases the likelihood of acute illnesses such as diarrhea, fever, and acute respiratory illness in children under 5 years by 9–18%. They also found that the effects of disasters vary significantly by gender, age, and socioeconomic characteristics.

In the context of inequality, Islam and Winkel (2017) identified three main channels through which the inequality-aggravating effect of climate change materializes, namely (a) increase in the exposure of the disadvantaged groups to the adverse effects of climate change; (b) increase in their susceptibility to damage caused by climate change; and (c) decrease in their ability to cope and recover from the damage suffered.

With this backdrop, it is clear that disasters have been more frequent due to climate change in India. Their combined effect has a significant bad impact on poverty and inequality. In this paper, we assess the impact of disasters and climate change on poverty and inequality in India. The main contributions of this paper are the following. First, to the best of my knowledge, it is the first paper to assess the impact of disasters and climate change on poverty and inequality in India by considering a panel data model. Second, state-level analysis is important to assess the state-level poverty and inequality caused by disasters and climate change for state-specific policy recommendations. Finally, it is the first rigorous quantitative assessment measuring the effect of climate change on poverty and inequality in India.

2. Data and Measurement of Variables

2.1 Disasters

To measure disasters in India we use data and methodology from the Centre for Research on the Epidemiology of Disasters (CRED), School of Public Health, Universitécatholique de Louvain, Belgium.[1]CRED categorizes natural disasters into six subgroups: geophysical (earthquake, volcanic activity, and mass movement), meteorological (storm, extreme temperature, and fog), hydrological (flood, landslide, and wave action), climatological (drought, glacial lake outburst, and wildfire), biological (epidemic, insect infestation, and animal accident), and extra-terrestrial (impact and space weather). Based on data availability and its applicability in the Indian context, we choose six types of disaster variables: drought, earthquake, extreme temperature, flood, landslide, and storm for the measurement of the natural disasters in India.

2.2 Climate Change

Climate change mainly refers to the rise in average surface temperatures of the Earth. The projected temperature changes by the Intergovernmental Panel on Climate Change (IPCC), based on General Circulation Model is about 2 to 4.7°C, with the most probable level being around 3.3°C by 2100 in the Indian subcontinent(IPCC, 2007). Indian scientists (Kumar et al. 2006;Lal and Harasawa 2001; Lal and Singha 2001), using the Hadley Centre regional climate model, also showed similar results and predicted that over the Indian region the temperatures will increase by 3–4°Ctoward the end of the 21st century. The greenhouse gas (GHG) emissions since the pre-industrial era have resulted in a massive increase in the atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Currently, India's

[1]More details about the CRED can be found from the following link https://www.emdat.be/.

CO_2emission from the energy sector is the fourth highest in the world, but is less than a quarter of China's level and half the US's level. However, India's emissions are likely to rise by 91–98% over the 2012 levels by 2030. At the same time, it is also projected that rainfall will increase due to variations in the spatial patterns. Most environmental models projected that rainfall would increase between 10 and 40% from the baseline period (1961–1990) to the end of 21st century, with the maximum expected increase in rainfall over north-western and central India[Mishra, 2014]. Data on the annual mean temperatures and annual rainfall of India are collected from the Ministry of Statistics and Programme Implementation, Government of India. Data on CO_2 emissions are collected from the World Bank (world development indicators).

2.3 Poverty and inequality

Inequality is measured by the familiar Gini coefficient. Poverty is measured by the poverty headcount ratio (PHR). The PHR is a percentage of the population living in households with the income per person below the poverty line. Due to the non-availability of income data at the individual level, we use expenditure survey data collected by theNational Sample Survey Organization (NSSO), Government of India (GoI). The NSSO started collecting data on a regular basis from as early as 1950–51. However, only from 1973–74, the sample sizes have been large enough to estimate poverty and inequality reliably in India. After 1970s, the surveys on consumer expenditure are being taken once in every five years, i.e., quinquennial surveys. Accordingly, the following nine rounds of large-size surveys have been conducted so far: 27 (1973–1974), 32 (1978), 38 (1983), 43 (1987–1988), 50 (1993–1994), 55 (1999–2000), 61 (2004–2005), 66 (2009–2010), and 68 (2011–2012).[2]We use unit or individual level data for the measurement of poverty and inequality in India.

Individual-level consumption data are calculated by considering different reference levels. The uniform recall period (URP) refers to consumption expenditure data collected using the 30-day recall or reference period. The mixed recall period (MRP) refers to consumption expenditure data collected using the one-year recall period for five nonfood items (i.e., clothing, footwear, durable goods, education, and institutional medical expenses), and 30-day recall period for rest of the items. Modified mixed reference period (MMRP) refers to consumption expenditure data

[2]However, the 55th Round for 1999–2000 cannot be compared with other rounds due to methodological (recall periods) differences followed in the survey. For more details, see the following links: http://mospi.nic.in/Mospi_New/upload/seminar_61R.pdf.

collected using the 7-day recall period for edible oil, egg, fish and meat, vegetables, fruits, spices, beverages, refreshments, processed food, pan, tobacco, and intoxicants. For all other items, the reference periods used are the same as in the case of MRP. While the URP-based consumption data are available all the rounds before 61st Round, MRP-based consumption data are available for all the periods (i.e., 61st, 66th, and 68th NSS Round surveys on consumer expenditure), and MMRP-based consumption data are available only for 66th and 68th NSS Rounds.

Measuring poverty in India poses two important challenges: first, the bundle of commodities, which are used to be “reasonable” for the poverty line bundle, could itself change, which causes problems for adjusting poverty line for inflation and comparison for a long period of time. The second issue is the various methodological improvements, which are recommended and implemented in various years by the various committees to upgrade the poverty line. These differences pose challenges for comparison. The committees that recommended poverty lines are Y. K.Alagh Committee (1979), Lakdawala Committee (1993), Tendulkar Committee (2004–05) and,most recently, Rangarajan Committee (2012).

3. Overview of Natural Disasters, Climate Change, Poverty and Inequality in India

3.1 Natural Disasters

The trends and patterns of natural disasters in India are presented in Table 1. To measure the natural disasters in India, we consider six variables. These are drought, earthquake, extreme temperature, flood, landslide, and storm. It has been observed over time that flood is the primary and common type of natural disaster occurring from 1900 to 2018, accounting for 296(i.e., 46%) of the total natural disaster events in India. The second highest event is storms, which make up 30% of the total natural disaster events occurring in India during the same time period. Both flood and storm constitute about 76% of the total events. Other 24% of the events comprise drought, earthquake, extreme temperature, and landslides in the period 1900–2018. Roughly, in the 118-year interval from 1900 to 2018, most natural disaster events occurred between 1961 and 2018. However, 56% of the total natural events occurred between 1991 and 2018. Flood is the top natural event reported within the same period of time. Overall, the analysis shows that over the years, the incidents of different types of disasters have increased sharply. Table 1 also shows that total deaths due to natural disasters have also increased over the period between 1900 and 2018. Almost 41% of the total deaths between1900 and 2018 occurred between 1991and 2018 due to natural disasters whereas 28% of the total deaths occurred between 1961and 1990 due to natural calamities. It is also seen that highest number of persons affected is due to drought, which is about 14 million, followed by flood, which affected 9 million in the time period 1900–2018. However, the highest damage reported is due to flood, which is about 65 million, during the same period of time. Overall, it shows that the total number of natural disasters, deaths, number of persons affected, and damage by the disasters is increasing over time, especially from 1991 onward. It is also important to note that 1991 was a year that brought a definite change, as India embarked on economic reforms that year through trade liberalization, financial deregulation, and making improvements in supervisory and regulatory systems and policies to make them more conducive to privatization and foreign direct investment (FDI) (Gopinath, 2008). Economic reforms have also had a positive effect on India's FDI inflows, economic growth, and trade volume. The average annual economic growth in India was about 4% in 1960–1990, but it increased to about 7% in 1991–2016. Also, the average merchandise trade (% of GDP) increased from 9.97% in 1960–1990 to 26.57% in 1991–2016. This clearly indicates that higher economic growth is responsible for natural imbalance and increasing natural disasters.

Table 1: Natural Disasters in India

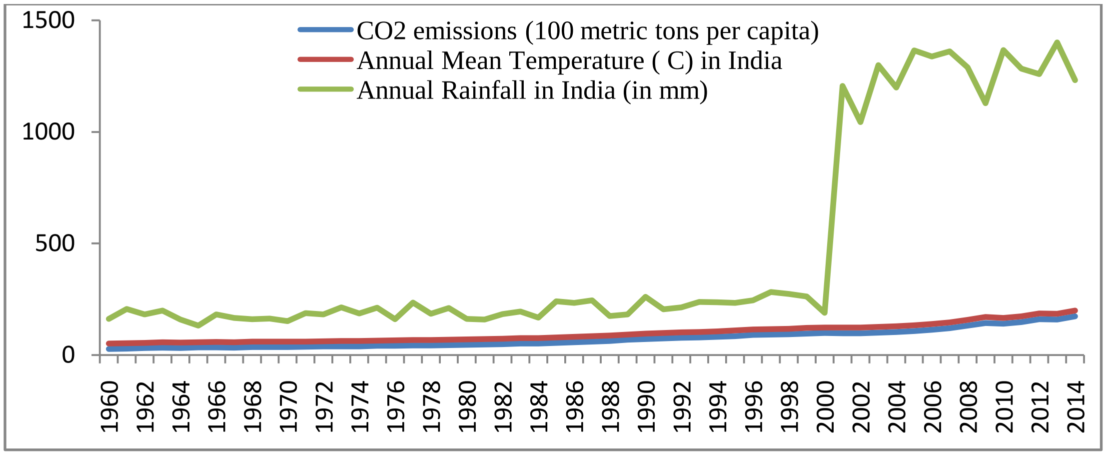
Natural Disaster	Number of Events	Percent share				Total deaths (Lakhs)	Percent share				Total affected (Billion)	Total damage (Billion US$)
	1900–2018 (%)	1990–1930	1931–1960	1961–1990	1991–2018	1900–2018	1990–1930	1931–1960	1961–1990	1991–2018	1900-2018	
Drought	15 (2)	7	7	47	40	42.5	29	35	35	0	13.9	5.4
Earthquake	32 (5)	3	13	38	47	0.8	26	10	1	63	0.3	5.3
Extreme temperature	59 (9)	0	3	36	61	0.2	0	6	21	73	0.0	0.5
Flood	296 (46)	1	6	24	70	0.7	0	2	44	54	8.7	64.6
Landslide	49 (8)	0	8	24	67	0.1	0	12	45	43	0.04	0.1
Storm	192 (30)	3	6	39	49	1.7	1	65	21	12	1.08	21.7

Source: Author's compilation based on data collected from EM-DAT.

3.2 Climate change

Trends and patterns of climate change variables are presented in Figure 1. It shows the increasing trend of climate change variables, which include per capita CO_2emissions, annual mean temperature, and rainfall in India. In 1960, the CO_2 emissions (metric tons per capita) was about 0.2682, which increased 1.73 (metric tons per capita) in 2014,a massive increase of 545%. The annual mean temperature has increased about 7% during the same time period. Most importantly, annual rainfall has increased steadily from 110.5 mm in 1960 to 1033.7 mm in 2014, which is again a phenomenal increase of 835%. It is also important to notice that annual rainfall has increased drastically from the year of 2000 onward. This indicates that climate change is happening rapidly and the rate of change is increasing quite sharply.

Figure 1: Climate change in India

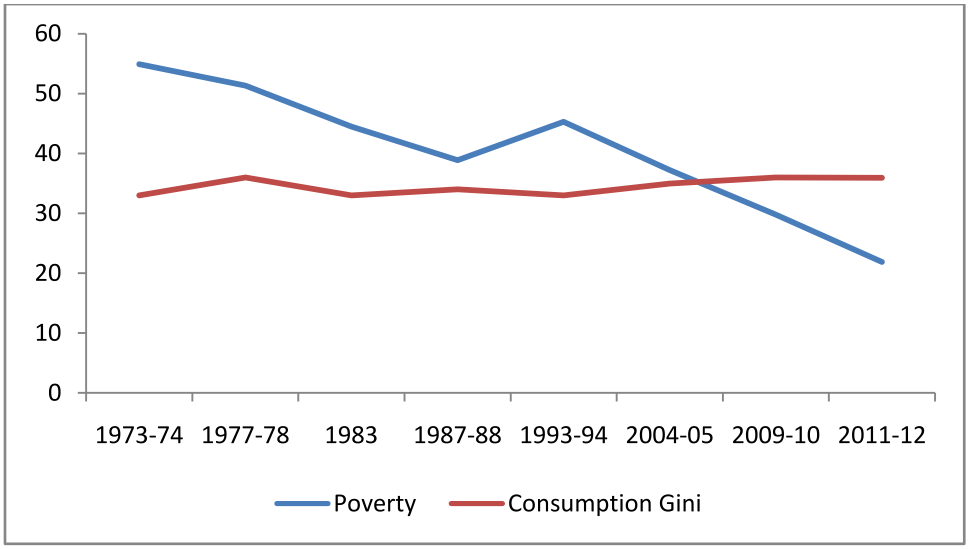


Source: Author based on data from various sources

3.3 Poverty and inequality

In Section 2.3, we discussed the problem of measuring and comparing poverty line for a long period of time. In Figure 2, we considered poverty figures based on two different methods of measurement calculated by Lakdawala Committee (1973–74 to 1987–88) and Tendulkar Committee (1993–94 to 2011–12). The poverty figures show a steady decline of poverty as measured by poverty head count ratio from 1973–74 to 2011–12. Going by the recommendations of the Tendulkar Committee on poverty line, poverty in India has decreased from 45.3% in 1993–94 to 21.9% in 2011–12, a decrease of 23.4%. Poverty and inequality figures contradict each other. Figure 2 shows that inequality in India increased from 0.33 in 1973–74 to 0.36 to 2011–12, which accounts for a 9% increase. The figure shows that the level of inequality in India is moderate, given that the Gini coefficient for middle-income developing countries tends to range from 0.400 to 0.500 and exceeds 0.500 in some of the countries with the most unequal distribution, such as those in Latin America. Such discussions clearly indicate that developing countries, such as India, are experiencing a higher level of inequality with a higher momentum for economic growth. Inequality in India is, however, not much highlighted due to the lack of credible data on income. Additionally, the other case is that, based on Kuznets curve, since India is one of the fastest growing developing countries in the world, inequality may increase initially but may decrease when India turns into a developed nation.

Figure 2: Poverty and inequality in India Combined (Rural + Urban)



Source: Author's compilation based on NSS survey on "Consumer Expenditure."

4. Effect of disasters and climate change on poverty and inequality

Now, we assess the effect of disasters and climate change on poverty and inequality in India.

For this purpose, we use following correlation matrix and regression analysis.

4.1 Correlation Matrix

Table 2: Correlation matrix of natural disasters, climate change, poverty and inequality in India (1973–74 to 2011–12)

	PR	CI	TND	TCO_2	AMTA	ARF
Poverty rate (PR)	1					
Consumption inequality (CI)	–0.5848 (0.1279)	1				
Total number of disasters (TND)	–0.4497 (0.2636)	0.4425 (0.2722)	1			
Total CO_2 emissions (TCO_2)	–0.9402* (0.0005)	0.6162 (0.1037)	0.4668 (0.2436)	1		
Annual mean temperature (AMTA)	–0.8470* (0.008)	0.7006 (0.0529)	0.7153* (0.0461)	0.9297* (0.0008)	1	
Annual rainfall (ARF)	–0.7819* (0.0219)	0.6646 (0.0722)	0.7691* (0.0257)	0.8798* (0.004)	0.9723* (0.0001)	1

* indicates statistical significance at the 5% level. *p*-values in parentheses.

Table 2 presents the Pearson correlation coefficient (*r*), which shows the strength and direction of the association between the two variables. Data ranges from 1973–74 to 2011–12 with eight time points (i.e., 1973–74, 1977–78, 1983, 1987–88, 1993–94, 2004–05, 2009–10, and 2011–12). Table 2 shows that poverty rate has a negative association with disasters and climate change. However, the only negative relationship of poverty with climate change is statistically significant. The values of the correlation coefficients show that poverty rate is negatively associated with CO_2 emissions (i.e.,r = –0.94), annual mean temperature (i.e.,r = –0.85)and annual rainfall (i.e.,r = – 0.78). The correlation values are high (i.e., r>0.5), which indicates that the association between climate change and poverty rate is very strong. It shows that that higher climate change reduces poverty rate. The probable reason behind this is higher economic growth. Higher economic growth or development increases economic activities, which increase the rate of climate change by higher CO_2 emission and at the same time, it decreases poverty rate. The negative relationship between poverty and number of natural disasters is also negative, but the value of–0.45 indicates that the association is medium or moderate. The value is not statistically significant. However, it indicates that increasing disaster is associated with a decline in poverty. In contrast, the total number of disasters and climate change variables has a positive association with inequality in India. The correlation coefficients range from 0.44 to 0.70. However, the values are not statistically significant. This indicates that though disasters and climate change have a positive impact on inequality, the association is not robust.

4.2 Regression analysis: Panel data model at the state level

Now we use panel data estimation to assess the impact of disaster and climate change on poverty and inequality in India. In Section 3, we have discussed the problem of generating time series/panel data for poverty and inequality in India and its comparison in different time periods. Only eight data points are available at the all-India level from 1973–74 to 2011–12. Keeping this in mind, we are taking the analysis to the state level in India. India, a union of states, is a sovereign, secular, democratic republic with a parliamentary system of government. There are 29 states and seven union territories in the country as of 2018. We consider all the states and union territories for the analysis. We consider the time period of 2004–05 to 2011–12 for our analysis. Particularly, three time periods – 2004–05, 2009–10, and 2011–12 – are considered for the regression analysis. These three periods are chosen by considering data availability and to make a consistent comparison of data for different time periods.

In order to measure urban poverty, the new limits for poverty line have been defined, as worked out by the Expert Group, which was set up by the Planning Commission of India in 2009 under the chairmanship of Professor Suresh Tendulkar to suggest a new poverty line.[3] Following the Expert Group's suggestion, the MRP-based poverty estimation is considered, as MRP-based estimates capture the household consumption expenditure of the poor households on low-frequency items of purchase more satisfactorily than the URP. We also use MRP-based inequality estimation for the analysis. Inequality is measured by the familiar Gini coefficient. On the other hand, poverty is measured by the poverty headcount ratio (PHR).[4]

To measure disaster and climate change, we use state-wise annual rainfall data by sourcing it from the Indian Meteorological Department (IMD), Ministry of Earth Sciences, Government of India. IMD provides subdivision-wise data.[5]We consider state-wise rainfall data for the measurement of disasters and climate change for the following reasons.

1. Comparable state-specific data are not available for increase of CO_2 emission, mean temperature, and number of disasters in India.
2. All-India level data shows that annual rainfall has a positive and statistically significant correlation with the annual mean temperature (r= 0.97), annual CO_2 emission (r= 0.88), and total number of disasters (r= 0.77). Therefore, annual rainfall stands as a good proxy for the measurement of disasters and climate change in India.
3. Table 1 shows that in the time period between 1991and 2018, flood is the most frequently occurring natural disaster in India. Total deaths, people affected, and properties damaged due to flood are also very high and are increasing sharply in recent times. For instance, recent floods in Kerala occurred due to higher than usual rainfall.

[3]Most recently, C. Rangarajan committee's recommended poverty lines are available in 2014 only for the period of 2009–10 and 2011–12. The Expert Group (Rangarajan) uses the modified mixed recall period (MMRP) consumption expenditure data of the NSSO as these are considered to be more precise compared to the MRP, which was used by the Expert Group (Tendulkar) and the URP. However, to compare poverty estimates for as long as possible, we could not use Expert Group's (Rangarajan) recommended poverty line for the analysis.

[4] Poverty line of Tamil Nadu is used for the Andaman and Nicobar Islands. The urban poverty line of Punjab is used for both rural and urban areas of Chandigarh. The poverty line of Maharashtra is used for Dadra & Nagar Haveli. The poverty line of Goa is used for Daman & Diu. The poverty line of Kerala is used for Lakshadweep.

[5]Joint data are available for Nagaland, Manipur, Mizoram and Tripura. As these states observe the same geographic conditions and share the border with another state, we divided the data equally for these states. In a similar way, we have done it for the state of Assam and Meghalaya as data available jointly for Assam and Meghalaya. However, for two union territories, Dadra & Nagar Haveli and Daman & Diu, we could not get rainfall data.

All these reasons prominently indicate that annual rainfall is suitable for the measurement of disasters and climate change in India.

4.2.1 Econometrics Model Specification

Our econometric model to investigate the impact of disaster and climate change on poverty and inequality in India, takes the following representation:

$$Poverty_{it} = \alpha_o + \alpha_i Rainfall_{it} + \delta_t + \eta_i + \epsilon_{it} \qquad (1)$$

$$Inequality_{it} = \beta_o + \beta_i Rainfall_{it} + \delta_t + \eta_i + \epsilon_{it} \qquad (2)$$

where η_i is the unobserved time-invariant specific effects; δt captures a common deterministic trend; ε_{it} is a random disturbance (assumed to be normal), and identically distributed with $E(\varepsilon_{it}) = 0$; Var $(\varepsilon_{it}) = \sigma^2 \succ 0$.

To choose between the panel data models, Breush and Pagan Lagrange multiplier (LM) test and the Hausman (H) specification diagnostic tests were conducted. The higher value (or significant) obtained in the LM test indicated the advantages in choosing random effect or fixed effect model over the pooled regression model.

4.2.2. Empirical Results

Ssummary statistics for each variable used in the regression analysis are presented in Table 3. The coefficient of variation (CV) is the ratio of the standard deviation to the mean. The higher of CV indicates grater the level of dispersion around the mean. It is expressed as a percentage. As it is unit free, it allows for comparison between distributions of values as scales of measurement are not comparable. Table 3 also shows that dispersion around the mean is highest for poverty followed by rainfall. This implies that a less symmetrical distribution for these variables. However, as the CV is lowest for inequality measurement, we can say that variation of inequality among the states is less compare to poverty and rainfall.

Table 3: Descriptive statistics for panel data

Variable	Observations	Mean	Std. Dev.	Min	Max	Coefficients of variation
Inequality (Gini)	105	0.30	0.05	0.16	0.43	31
Poverty (%)	100	23.87	13.45	0.40	57.20	3363
Rainfall (mm)	96	1499.03	1118.72	130.47	5779.70	857

Source: Authors' calculation based on 308 observations.

Table 4 presents the correlation coefficient of the variables used in the regression analysis. It shows the correlation between rainfall and poverty is positive, but it is not statistically significant. The correlation between rainfall and inequality is positive and statistically significant. This implies that rainfall has a greater impact on inequality than poverty.

Table 4: Correlation coefficient of determinants of gross domestic product

Variable	Inequality	Poverty	Rainfall
Inequality	1.0000		
	0.0004		
Poverty	(0.9971)	1	
	0.3508*	0.1019	
Rainfall	(0.0005)	(0.3309)	1

* indicates statistical significance at 5% level. *p*-values in parentheses.

Table 5: Impact of changing rainfall on Poverty and Inequality in India: Panel data

Independent variable	***Dependent variable:***					
	Log of State-Wise Inequality			***State-Wise Poverty***		
	RE	***Pooled OLS***	***FE***	***RE***	***FE***	***OLS***
	(1)	(2)	(3)	(4)	(5)	(6)
Log of state-wise annual rainfall	0.019	0.038*	-0.003	1.656	8.36*	1.41
	(0.028)	(0.022)	(0.039)	(1.405)	(4.81)	(1.35)
Intercept	-1.35***	-1.48***	-1.19***	13.39	-33.58	15.18
	(0.196)	(0.158)	(0.281)	(10.02)	(33.71)	(9.61)
Overall R^2	0.0299	0.0299	0.0299	0.0083	0.0083	0.0083
Wald chi^2/F Model test	0.53	2.90*	0.01	1.39	3.03*	1.09
Number of observation	96	96	96	93	93	93

*Note: Figures in parentheses represent standard errors. *** and ** indicate statistical significance at 1% and 5% level, respectively.*
Source: Estimated by using equation (1 and 2).

Table 5 presents the estimated results using equations 1 and 2. To assess the impact of rainfall on inequality, we find that pooled ordinary least square (OLS) method shows the best-model fitting compared to random effect and fixed effect models. Regression model 2 shows that state-wise rainfall has a statistically significant (at 10%) positive effect on log of state-wise inequality. As dependent and independent variables are in logarithmic form it can be considered as elasticity. In particular, a 10% increase in state-wise rainfall increases inequality by 0.38%. This indicates that disaster and climate change have a positive effect on inequity in India. Regression model 5 shows that fixed effect model is more suitable than random effect and pooled OLS model. It is the Liner-Log model. The estimated result shows that a 1% increase in log of state-wise annual rainfall leads to 0.84% increase in the state-wise poverty rate. Therefore, we conclude that disaster and climate change have a positive effect on increasing poverty and inequality in India.

5. Conclusions and policy recommendations

The present paper assesses the impact of disasters and climate change on poverty and inequality in India from 1900 to 2018. By sourcing data from Centre for Research on the Epidemiology of Disasters, we measure natural disasters by considering drought, earthquake, extreme temperature, flood, landslide, and storm in India. Climate change is measured by annual mean temperature, annual rainfall, and CO_2 emissions. These variables are collected fromMinistry of Statistics and Programme Implementation, Government of India and World Bank. Using National Sample Survey data on consumption expenditure, we calculate the poverty head count ratio and Gini coefficient to measure the poverty and inequality in India for the analysis. Correlation coefficients and panel data models are used to assess the impact of disaster and climate change on poverty and inequality in India.

Descriptive statistics show that the occurrence of natural disasters in India is increasing over time. Most importantly, flood is the most occurring natural disaster that happen frequently than other forms of natural disasters in India. Total deaths and number of persons affected due to the natural disasters have also increased over the same period of time. Climate change variables show that there is a 545% increase in the CO_2 emissions and 7% increase in the mean temperature from 1960 to 2014. Most importantly, annual mean temperature has increased by835% during the same period in India. Poverty figures show that there is a 23.4% decline in poverty from 1993–94 to 2011–12. On the other hand, inequality in India has increased from 0.33 in 1973–74 to 0.36 to 2011–12, which represents a 9% increase.

Correlation coefficients show that poverty rate is negatively associated with CO_2 emissions (i.e. r=–0.94), annual mean temperature (i.e.,r^2=–0.85), and annual rainfall (i.e.,r=–0.78). The estimated values are statistically significant. It indicates that climate change, which is the outcome of higher economic growth, has a negative effect on poverty rate in India. In contrast, though inequality was positively associated with disasters and climate change variables,it is not statistically significant.

Finally, state-wise panel data model analysis from 2004–05 to 2011–12 shows that natural disaster and climate change, which is measured by changing rainfall, has a positive and statistically significant effect on state-level poverty and inequality in India. In particular, a 10% rise in annual rainfall increases state inequality (or poverty) by 0.38 % (or 83%) in India.

Finally, we propose the following suggestion to the policymakers: first, we need to think how economic growth strategy could be redesigned so that it should take disaster and climate change into consideration. Though higher economic growth reduces poverty and inequality, it also increases climate change and disasters, which are responsible for increasing poverty and inequality. This trade-off has to be worked out properly in light of the work that won the Nobel Prize for Economics this year. Second, we suggest that use of eco-friendly technology in industrial production and consideration of strong redistributive policies are essential to eradicate poverty and inequality in India.

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